Space Weather Technical Forecast

Issued on Monday, 19 December 2022 at 01:00 Local

This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: M-class flares Likely. Slight Chance of Minor Geomagnetic Storms until midweek.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been Low over the past 24 hours, with occasional mid-ranking C-class flares observed at GOES16, peaking with a C5.8 at 18/1010UTC, with this event associated with AR3162. Many of the other similar-magnitude flares originated from AR3169 in the northeast. AR3169 also showed the most notable growth tendency over the 24 hours, with significant development in its trailing and intermediate spots. This group now covers a significant span, although it may be better described as a large Zurich Esi followed by still another new sunspot group at a slightly higher solar latitude, with the latter perhaps a Dao on the limb. Both groups are difficult to discern fully at present given their proximity to the northeastern horizon, and a possible Mt Wilson delta spot may be present in AR3169's central region for example.

Figure 0: Sources of the UTC weekend's X-ray flare activity of C-class and above, with the departing Ex-AR3165 (in the southwest) and arriving AR3169 (in the northeast) the main foci of activity. Image courtesy of SIDC ROB.

The above were two of up to nine sunspot regions on the current Earth-facing side. Growth in other regions was generally more limited, with AR3166 and AR3167 both seeing slow changes in their

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intermediate spots, while AR3163 became more open as its central spots faded.

There remain numerous filaments on the disc, although none obviously erupted in the 24 hours. There were numerous Coronal Mass Ejections (CMEs) observed on Lasco coronagraphs in the period, with six analysed thus far. Of these, four were considered far-sided western solar hemisphere events, one was tied to the 18/1010UTC flare but was directed west and north of the Sun-Earth line despite its southern hemisphere origins. The sixth was a narrow eastward directed CME, with an uncertain source. In all cases, these were off the Sun-Earth line. No new Earth-directed CMEs were therefore in evidence in the period, although given the cadence of new emissions, further CMEs are expected to materialise on coronagraphs in the coming hours.

Solar Wind / Geomagnetic Activity: Solar winds, as observed at L1 by DSCOVR followed a slow regime for much of the period, but with a slight enhancement observed in the UTC evening of an as yet uncertain provenance. Possible explanations include either a CIR in advance of CH54/-, or perhaps the 15 December CME passing close by.

The solar wind speed oscillated slightly about an average of 300km/s, with a late increase to 325km/s. The solar wind density was near the long-term average of single figures ppcc for the majority of the reporting window, with a similar late increase to nearer 10ppcc. Of more significance, the IMF showed a rising tendency, from near 5nT to peak near 15nT, with the north-south component remaining more modest in scope between +/-8nT. The phi angle was negative (towards the Sun) throughout.

The net effect of the above solar wind measures was nevertheless for provisionally Quiet geomagnetic activity throughout, peaking late in the 24 hours with a Kp of 2o in the 21-24UTC interval as the IMF increased.

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10MeV) as measured at GOES16 remained at Background levels.

High energy electron flux (greater than 2 MeV), as observed by GOES16, was at Background to Moderate levels. The associated 24-hour fluence was roughly level and well below Active (1e8 integrated pfu). Observed fluence at 19/0001UTC was 1.99e6 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity is Likely to remain at Moderate levels, with up to nine sunspot regions on the disc at present. Successive departures over the western solar horizon through the period may be compensated for by hints of large arriving regions in the east, although this aspect of the forecast is lower confidence, and for now the risk is held constant throughout.

Solar Wind / Geomagnetic Activity: Up to two CMEs from 14 and 15 December have now most likely passed 1AU to no effect at Earth, although the latter may still arrive as a glancing blow with muted effects very early on day one, Monday 19 December.

The forecast otherwise comprises two fast wind streams: firstly the imminent high speed stream from CH54/-, which perhaps offers a Slight Chance of G1 on Monday 19 December. After a lull into Tuesday, a second fast wind from CH55/+ may arrive before midweek to give the peak risk of G1 for the four-day period, albeit still a small risk given our proximity to the solstice. The most reliably Quiet day is now perhaps Thursday 22 December as CH55/+ matures.

Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux is expected to remain at Background levels throughout, although there is slight chance of S1 level storms with the occurrence of any notable flares.

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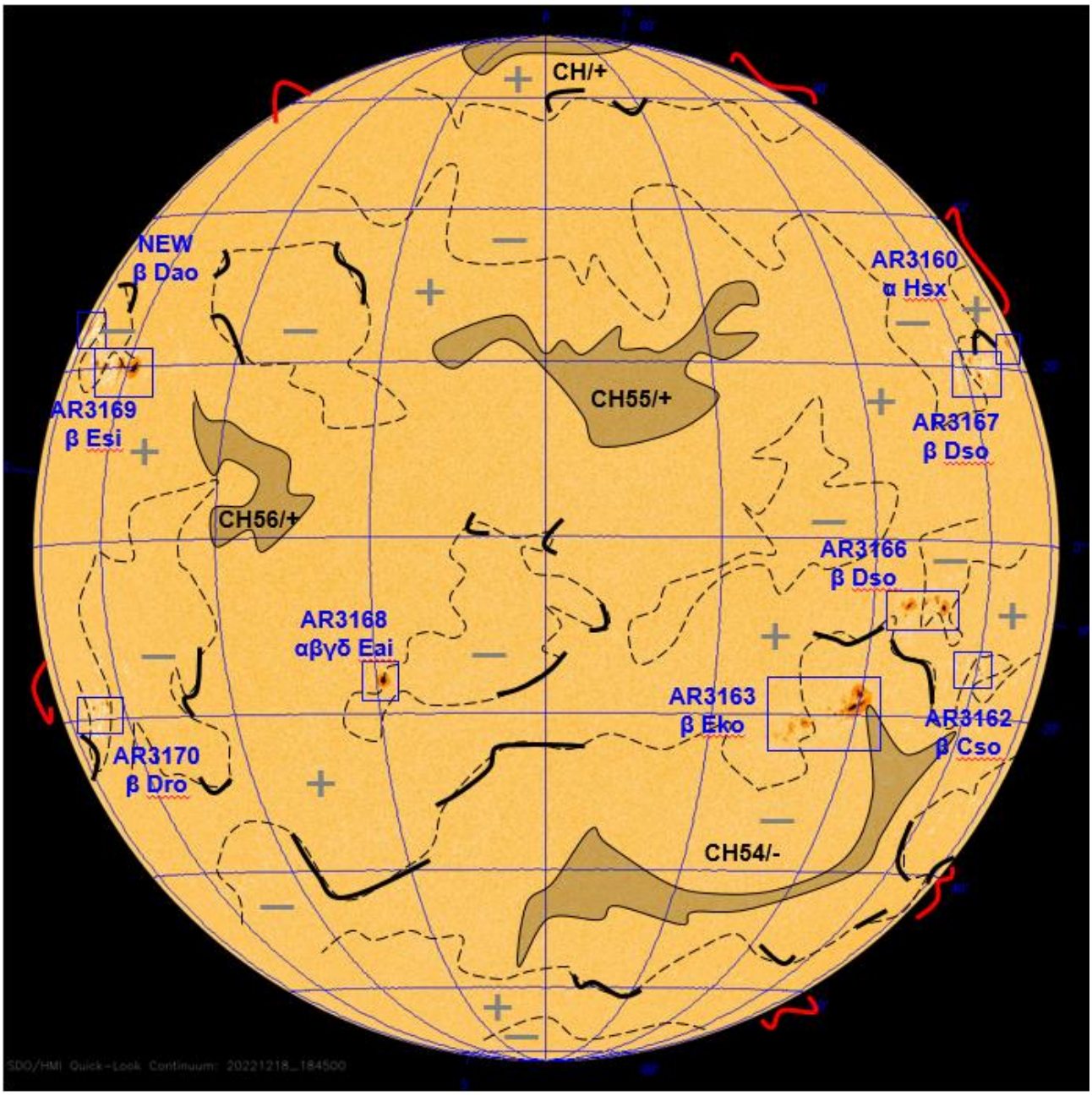
High energy (greater than 2 MeV) electron flux is currently at Background to Moderate flux, and expected to persist at these levels. The associated 24-hour fluence is expected to continue well below the Active (1e8 integrated pfu) threshold with a mostly flat trend anticipated.

Figure 1. Solar Analysis Valid 18/1845UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

Two minor Coronal Mass Ejections (CMEs) dating from 14 and 15 December have now most likely passed 1AU to no effect at Earth, although there is perhaps a residual slight chance that the latter is still outstanding.

Recent STEREO A MAG and PLASTIC measurements suggest that a negative polarity fast wind is developing at the satellite, which puts geoeffectivity later on day one, Monday 19 December, with around 400km/s seeming a realistic peak. This may combine with any residual 15 December CME risk to give a Slight Chance of G1, although being very near the solstice (and therefore the semi-annual coronal hole minimum potency) suggests that significant activity is unlikely, as on previous passes of this feature.

There should then follow a lull before the more assured arrival of a second fast wind from CH55/+, with MOSWOC Enlil perhaps indicating speeds of around 500km/s are more feasible. Because of a more advanced western edge to this hole than on last pass, it may just arrive at the very end of the UTC day of Tuesday 20 December, else continuing into midweek with a further Slight Chance of G1.

Confidence in Tuesday being a more reliably Quiet day has therefore fallen compared to recent guidance, with the quieter window instead transferred to after the onset of CH55/+ on Thursday 22 December. Wednesday is perhaps the most likely day to see minor geomagnetic activity, although even this should be muted given the time of year.

Geo-Magnetic Storm	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Minor or Moderate	G1 to G2	No	10	5	20	1
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
14/1530	Partial	Filament	SW	400	Assumed to have passed 1AU Sunday	Probable miss
15/1743	Partial	Unknown	NE	790	Imminent or passed 1AU	Low confidence

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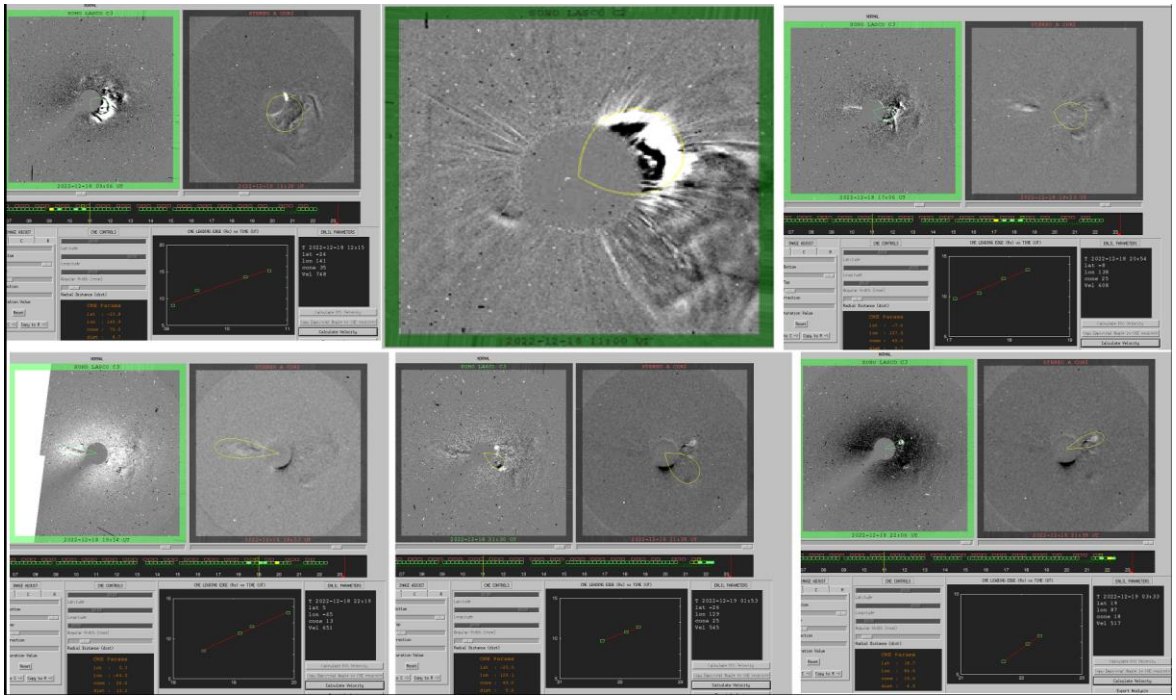
Figure 2: Rogues' gallery of up to six CME candidates seen on coronagraphs in the UTC day of Sunday 18 December. All cursory analyses are far-sided with the exception of one emanating from the 18/1010UTC flare, which probably leads the Earth in its orbit to no effect (larger image); and also a narrow CME of uncertain provenance that is considered to be travelling east of the Sun-Earth line (lower left image).



Radio Blackouts - X-Ray Flares:

There are now up to nine sunspot regions on the solar disc, with some signs that a higher latitude portion of emerging AR3169 in the northeast may constitute a new spot region. The main changes in the sunspots on the Earth-facing side were seen in AR3169 especially, with areal growth and proliferation in its trailing portion, although this was not capped by significant X-ray activity.

The front-side population of sunspot groups is likely to be in a constant state of flux in the period, with the successive departures of AR3160, AR3162 and AR3167 over the western horizon perhaps countered by new regions arriving over the eastern limb. Of particular import is a large region suggested by far-side soundings and some halo CMEs in the last working week. This may arrive into the current UTC working week to bolster the recently-reduced risk of significant flares, although any contribution from this has yet to be determined.

X Ray Flares	**Level**	**Past 24 Hours (Yes/No)**	**Day 1 (00-24 UTC)**	**Day 2 (00-24 UTC)**	**Day 3 (00-24 UTC)**	**Day 4 (00-24 UTC)**
Probability			**(%)**	**(%)**	**(%)**	**(%)**
Active	**R1-R2 M Class**	No	50	50	50	50
Very Active	**R3 to R5 X Class**	No	5	5	5	5

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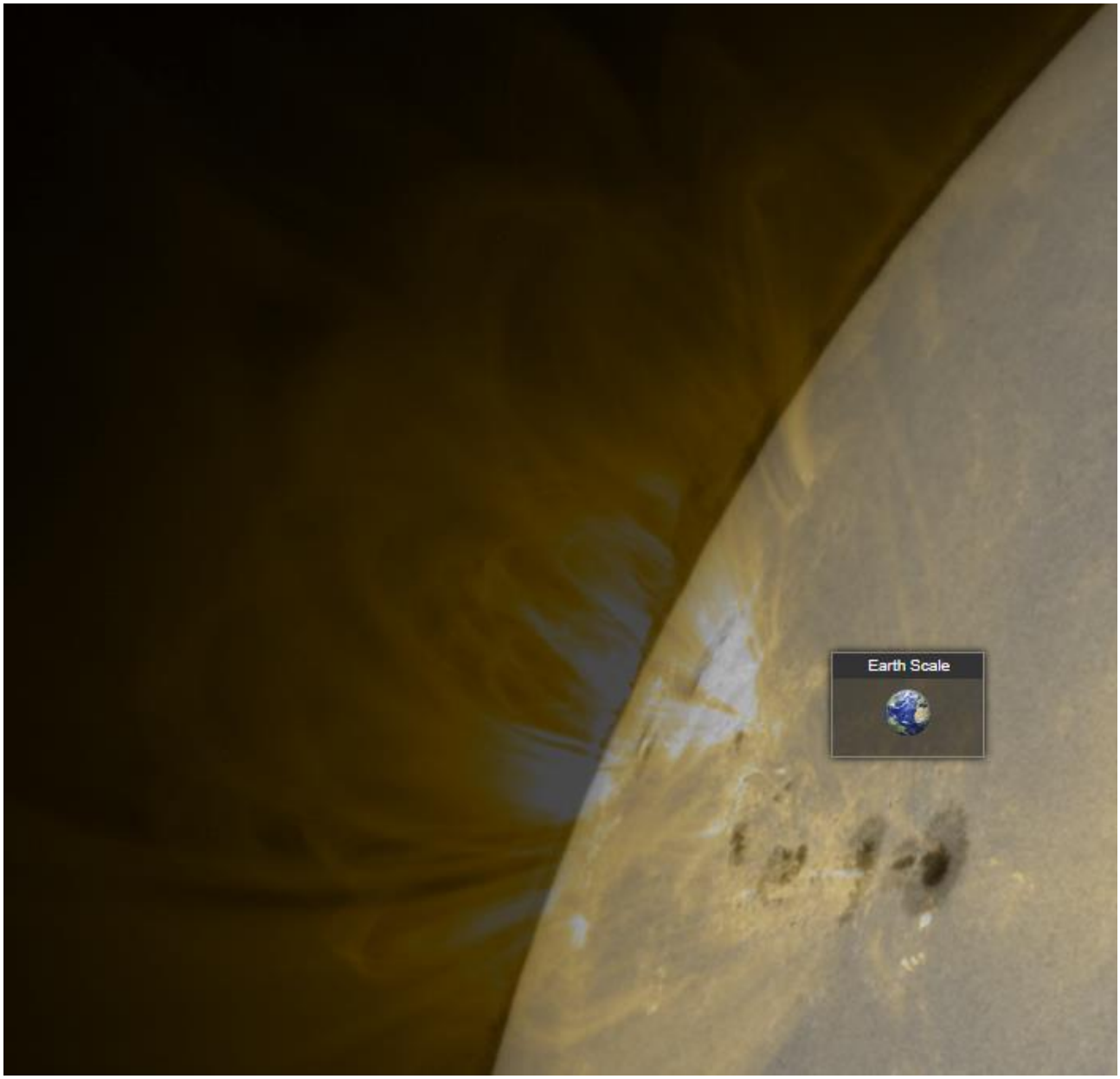
Figure 3: Helioviewer.org-derived composite image of HMIIF and AIA171 imagery for 18/2300UTC, showing the northeast limb sunspot(s) of AR3169 and perhaps a trailing group. Earth also shown for scale.



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Solar Radiation Storms - (High Energy Protons):

The high energy proton flux (greater than 10 MeV) will most likely continue at Background levels, however there is a Slight Chance throughout of a S1+ event. This chance is held slightly higher when compared with the raw disc probabilities at first due to the presence of Ex-AR3165, which remains in a geoeffective location just over the southwestern solar horizon for the time being. There is also the possibility of an increase in probabilities later in the period with recent far-sided CME and flare activity approaching the east limb, but this will be assessed as and when these present for analysis.

Radiation Storms Probability (Exceedance)	**Level (cm^{-2} sr^{-1} s^{-1})**	**Past 24 Hours (Yes/No)**	**Day 1 (00-24 UTC) (%)**	**Day 2 (00-24 UTC) (%)**	**Day 3 (00-24 UTC) (%)**	**Day 4 (00-24 UTC) (%)**
Active	**≥ S1**	No	15	10	10	10
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

High Energy Electrons Event (≥ 2MeV):

High energy (greater than 2 MeV) electron flux is following a stable low magnitude diurnal oscillation at present. Whilst CH54 and CH55 may become geoeffective in turn in the period, neither is currently envisaged as being capable of giving Active 24-hour integrated fluence, on a par with previous rotations. Confidence in this is perhaps lower than average, with both of these coronal holes' geometries changed since last pass, as well as the possible complicating presence of up to two CMEs - although in all likelihood these have now passed 1AU to no discernible effect. For its part, MOSWOC REFM suggests current modest electron fluence levels should persist throughout, although this does not allow for any transient activity.

GEO Electron Environment Probability (Exceedance)	**Level (cm^{-2} sr^{-1} day^{-1})**	**Past 24 Hours (Yes/No)**	**Day 1 (00-24 UTC) (%)**	**Day 2 (00-24 UTC) (%)**	**Day 3 (00-24 UTC) (%)**	**Day 4 (00-24 UTC) (%)**
Active	**≥ 2 MeV ≥ $1x10^8$**	No	1	5	10	30
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

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